Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending September 19, 2020, are as follows:

NSTX-U RECOVERY (J. GALAYDA) AND RESEARCH (S. KAYE)

Recovery (J. Galayda):

Coils — Of the five coils (PF1B#1, PF1C#1, PFC#2, PF1A#1, and PF1A#2) at PPPL, two passed low-power electrical tests on site; the remaining three are on the cusp of testing. In France at Sigmaphi, PF1B#2 was successfully electrically tested and was packaged for shipping. In addition, winding and brazing was completed on PF1C-S (spare) and was prepped for vacuum pressure impregnation (VPI). The winding on PF1A-S of layer 4 of 4 winding layers is almost completed.

Center Stack Casing (CSC) — The CSC welding of the collar pieces was finished at Turtle Creek and the CSC was transported to Camden, New Jersey to finish final machining over the next eight weeks. Additional welding of the organ pipes occurred at Turtle Creek and the welding of the mockup bellows to the flange will follow. In addition, post-machining vacuum testing of all of the trimmed spare bellows neared conclusion at PPPL so that they could be sent to ORT/Holtec for installation.

Machine Core Structure (MCS) — Many fabrication activities continued at the three facilities currently making sling parts. Precision Boring in Michigan continued fabrication of the PF1A and PF1B capture and common flanges and PF1C capping flanges for the sling supports, which are due to be shipped in the next couple of weeks. In South Carolina, Carolina Fabricators production of PF1A sling parts continued and will continue until the end of September. Also, G. J. Oliver added components to the machined PF1C supports and will ship the supports out for coating in the near term, with delivery of the lower PF1C support scheduled for the end of the month. Additional procurement activities to award contracts for the remaining MCS components neared completion. The on-site mockup activities continued and will wrap up in the next two weeks, with the output to be incorporated into assembly procedures. PF1B lower slings were welded together, with PF1A lower slings to follow. In addition, the lateral support shim peer review was successfully conducted this past week.

IVPS — Preparations on-site began for installation of power to the vacuum pump and to perform mechanical installations of the vacuum system components in late September, to be followed by electrical and controls work in October.

PF Bus Supports — The design, analysis, and drawing efforts for coil flag position changes continued, along with finalization of drawings. Procurement activities continued in series to final drawing updates.

Lateral Support Shim Peer Review — A peer review was held Sept. 15 to resolve the design issue of lateral support shims in between the machine core structure's casing assembly and the outer vessel so that redesign of the support shims can be finalized with proper integration of machine instrumentation. This will help monitor the upper casing motion using the displacement and strain sensors installed on the support shims.

Aquapour Wire Peer Review — A peer review was held Sept. 17 to resolve any potential issues for the Aquapour wire identified in an updated calculation, and to quantify the impact of the electrical field stress to the insulation system. A statistical electrical field analysis was performed for a final design review (FDR) held in Dec. 2019 to evaluate the Aquapour and four wires effects to the TF and OH coil insulation system. It was concluded at that time that the existence of Aquapour and the wire will not affect the normal operation of NSTX-U if the wires were left floating. Additional analysis has been performed since the FDR to include more extreme cases of the air bubble location and its impact to the electrical field distribution to ensure negligible effect to the TF/OH insulation system. This review examined the latest electrical field calculation based on the assumptions of the most extreme air bubble condition and location, in order to confirm and ensure consistency of the design resolution of the wire presented at the Dec. 2019 Magnet RP scope FDR.

Research (S. Kaye):

NSTX-U researchers are continuing a series of discussions with newly funded diagnostic and science collaborators to discuss work scopes, plans, and needs. These discussions will inform NSTX-U plans for defining and/or refining plans for diagnostic implementation and PPPL support for that, as well as for the science collaborations.

ITER PROJECTS (H. NEILSON)

The Laboratory's ITER Diagnostics team is contributing to an important initiative of the U.S. ITER Project Office to update its estimate at completion (EAC) for all remaining diagnostic and port integration design work. This week a briefing for U.S. ITER management was presented by Project Control Manager E. Nassar, explaining the methodology used by PPPL in developing the estimate that was submitted earlier in the month. Nassar explained how the team's experience in developing preliminary and final designs for the Low Field Side Reflectometer (LFSR) project has informed its understanding of design costs for all its systems and led to revised estimates. The team began preparing briefings on its individual sub-projects, scheduled for next week, which will explain the estimates in more detail and respond to questions.

Captive Overhead Supports (M.-A. de Looz):

A captive supports team is developing a plan to finalize the design of overhead structures that will support transmission lines and safety barriers for the LFSR and Toroidal Interferometer Polarimeter (TIP) diagnostics. These structures must be installed during first plasma assembly since their ceiling attachment points will become inaccessible later, hence they are termed "captive" supports. The team, including engineers A. Buahin and M. Mansour attended final design reviews for two other systems, drawing lessons learned that have informed their plans. Based on this input, the team is finalizing its proposed scope definition and deliverables list, while continuing to move forward on the system design.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates):

A manuscript by M. Landreman (Univ. of Maryland) and C. Zhu entitled, "Calculation of permanent magnet arrangements for stellarators: A linear least-squares method" has been submitted to *Plasma Physics and Controlled Fusion*. In this paper, the authors report the development of a robust and efficient algorithm, REGCOIL_PM, that calculates the spatial distribution of permanent magnets for stellarators. The procedure involves a small number of fixed-point iterations, with a linear least-squares problem solved at each step. Halbach solutions are found naturally and the magnitude of the magnetization can be made uniformly equal to a target value.

THEORY (S. HUDSON)

M. Churchill presented a talk at the virtual Smoky Mountain Conference entitled, "Machine Learning for the Complex, Multi-scale Datasets in Fusion Energy."

A paper by N. Lopez and I. Dodin titled, "Restoring geometrical optics near caustics using sequenced metaplectic transforms" was published in New Journal of Physics: https://doi.org/10.1088/1367-2630/aba91a. This paper reports how to calculate electromagnetic-field structure near general caustics, including multidimensional fold and cusp caustics, using ray optics, which is usually considered impossible.

A paper by D. Garg and I. Dodin titled, "Average nonlinear dynamics of particles in gravitational pulses: effective Hamiltonian, secular acceleration, and gravitational susceptibility" was published in *Physical Review D*: https://doi.org/10.1103/PhysRevD.102.064012. This paper introduces the concept of ponderomotive force and linear susceptibility for gravitational interactions and thus

prepares a foundation for rigorous calculations of gravitational-wave dispersion in non-vacuum settings.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard):

The Office of Communications posted two press releases to the PPPL website. The first reported on this year's cohort of interns who spent time virtually at PPPL as part of the DOE's Student Undergraduate Laboratory Internship (SULI) and Community College Internship (CCI) programs. The second reported that H. Neilson will receive the 2020 Institute of Electrical and Electronics Engineers' (IEEE) Nuclear & Plasma Sciences Society (NPSS) Merit Award for decades of achievement, including his contributions to plasma physics research and for overseeing projects in collaboration with fusion experiments around the world from the Wendelstein 7-X (W7-X) stellarator in Germany to the international ITER experiment in the south of France. Both stories were also posted to the *Newswise* and *EurekAlert* press release distribution services.

DIRECTOR'S OFFICE (S. COWLEY)

Laboratory leadership hosted a virtual all-hands meeting on Sept. 14 to provide various updates about the Laboratory and answer questions from employees.

The PPPL Advisory Board met Sept. 16-17. The purpose of the board is to provide an outside independent review of PPPL science and operations. The board then provides Princeton University with feedback and recommendations.

D. Graves, S. Cowley, and J. Menard participated in a webinar titled, "An Allied Approach to Semiconductor Sector Competitiveness" on Sept. 17.

J. Menard participated in the monthly virtual National Laboratory Chief Research Officers (NLCRO) meeting and bi-weekly National Virtual Biotechnology Laboratory (NVBL) working group call on Sept. 18.

S. Cowley participated in the bi-weekly virtual National Laboratory Directors Council (NLDC) Coordination meeting on Sept. 18.

This report is also available on the following web site:

http://www.pppl.gov/publication-type/weekly-highlights